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Dense Membranes for Anode Supported all Perovskite IT-SOFCs

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The intent of the project is to develop inexpensive oxygen permeable, dense and high surface area membranes in the form of bulk and highly oriented thin films using soft solution chemical routes and pulsed laser deposition (PLD) technique for fabricating natural gas fuelled anode supported all perovskite planar intermediate temperature (IT)-SOFCs. We have optimized the process conditions by the combined approach of sol-gel and microwave processing is unique because it is simple, rapid, energy efficient and yields materials of excellent phase purity with good densification. Simultaneously, we have also synthesized nano scale electrolytes with high ionic conductivity (higher than 10^{-2}S cm^{-1}) over a wide range of temperature and oxygen pressure and low electronic conductivity. The influence of preparation techniques on the microstructure, grain-size and consequently on the electrical transport properties of the ABO_3 structured materials used as electrode and electrolytes in all perovskite IT-SOFC were investigated. The wet chemical methods like metal-carboxylate gel decomposition, hydroxide co-precipitation, sonochemical and regenerative sol-gel process followed by microwave sintering of the powders have been used. Microwave sintering parameters were optimized by varying sintering time, and temperature to achieve higher density of pellets. Nano-crystalline perovskites with multi-element substitutions at A- and B-sites to achieve physico-chemical compatibility for fabricating zero emission all perovskite IT-SOFCs are reported in this poster.

In the last two years, we have focused on obtaining well sintered dense LSGM electrolytes, porus lanthanum strontium manganite (LSM), lanthanum strontium ferrite (LSF), lanthanum strontium cobalt ferrite (LSCF), lanthanum nickel ferrite (LNF) electrodes, and lanthanum chromium ferrite (LCF) as interconnect at low temperatures for developing miniaturized SOFC cell and stacks working at 600-800 ^{0}C. Various compositions of ceria, and Gd-doped ceria were prepared using wet chemical methods. Simultaneously, we have also investigated dense proton conducting (PC) perovskite membranes such as $SrCeO_3$, $SrCe_{1-x}M_xO_3$ compositions were synthesized by sonochemical treatment followed hydrothermal method and sintering is done by microwave heating. The materials were tailored to be used as anode, cathode, and electrolyte and interconnect in solid oxide fuel cells (SOFCs). The materials were characterized by XRD, TEM and other spectroelectrochemical methods. Electrical conductivity of the compositions was measured by electrochemical impedance spectroscopy (EIS). These experiments were carried out to optimize the composition and various properties of the materials to be used in CH4 fuelled

SOFCs. An investigative study was performed for developing materials to fabricate natural gas fueled SOFC hybridized to a gas turbine (SOFC-GT) to enhance power production and maximum utilization of resources in Trinidad.

The XANES and XPS measurements of these complex perovskites prepared in this work are under progress. In addition to the above work, we have attempted to develop proton conducting perovskites, and apatites to be used as SOFC components for reducing the operation temperatures of the fuel cells. The following systems are investigated:

1) Hydroxy apatites. $Ca_{10}(PO_4)_6(OH)_2$, stoichiometry and off-stoichiometry compositions prepared by (i)urea combustion , (ii) ball-milling (iii) hydrothermal (iv) Sonochemical reaction. Mg and Sr substitution at Ca site has also been carried out. Structural and phase behaviour investigations are in progress.

2) $Gd_{1-x}Ca_xCoO_3$ systems as novel lectrodes for SOFC and optimization of substitution to find its phase stability and solid solubility of aliovalent and isovalent ions in these matrixes. Glycine nitrate method is used to prepare these compositions

3) $LaCr_{1-x}M_xO_3$, M= Mn, Mg, Co, Fe , x=0.1as interconnect materials and catalytic applications. Phase stability and structural transformation due to substitution on Cr site. Glycine nitrate method is used to prepare these materials.

4) $LaNi_{1-x}Fe_xO_3$, x= 0.1 –0.9 , cathode materials and sensor applications, Glycine nitrate method is used to prepare these materials.

5) $SrCe_{1-x}M_xO_3$, M= Dy, Er, Eu, Tb, , x=0.1as proton conducting perovskites and its phase stability with respect to the rare earth substitution.

We are assembling the cell and planning to evaluate the cell performance. Two undergraduate and three graduate students were supported with this grant along with a senior research associate since 4/30/2004. The effort in this project yielded 6 publications in the refereed journals, and five papers in the conference proceedings.

1. Novel wet-chemical synthesis and characterization of nanocrystalline CeO_2 and $Ce_{0.8}Gd_{0.2}O_{1.9}$ as solid electrolyte for intermediate temperature solid oxide fuel cell (IT-SOFC) applications, B.Rambabu, Samrat Ghosh and Hrudananda Jena, J. Mater. Sci. (in press, 2006).

2. An exploratory study on solution assisted synthetic routes to prepare nano-crystalline $La_{1-x}MxGa_{1-y}NyO_3$ (M=Sr, N=Mn,Mg) for IT-SOFC applications. Hrudananda Jena and B. Rambabu, Mater. Chem. Phys. (in Press, 2006).

3. Innovative processing of dense LSGM electrolytes for IT-SOFC's, B. Rambabu, Samrat Ghosh, Weichang Zhao and Hrudananda Jena, J. Power Sources (Accepted)

4) Nanostructured Bulk and Thin Films of $LaSrMnO_3$, K.I. Gnanasekar, Xin Xiang, Josef Hormes, Ronald Tilts Worth, Mher and B. Rambabu, Solid State Ionics 148 (2002) 575-581

5. Effect of sonochemical, regenerative sol gel, and microwave assisted synthesis techniques on the formation of dense electrolytes and porous electrodes for all perovskite IT-SOFCs, Hrudananda Jena, and B. Rambabu, Journal of Fuel Cell Science and Technology, 2006.

6. Proton Transport in Nanocrystalline Hydroxy apatite $(Ca_{10}(PO_4)_6(OH)_2$, Hrudenanada Jena, and B. Rambabu, Accpeted for publication in the Journal of Materials Science.